PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2002-287175
(43)Date of publication of application : 03.10.2002

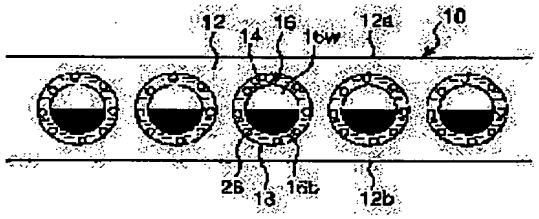
(51)Int.CI. G02F 1/167

(21)Application number : 2001-084897
(22)Date of filing : 23.03.2001

(71)Applicant : MINOLTA CO LTD
(72)Inventor : SAKAMOTO KAZUHIRO
NAKANE YOSHIKI
YAMAKI HIDEO
YOSHIDA SHIGETAKA
MATSUURA SHINYA

(54) TWISTING BALL DISPLAY SHEET

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a twisting ball display sheet which can stably keep an image even when accidental triboelectrification or dissipation of retention charges occurs after the image is written.
SOLUTION: The twisting ball display sheet 10 has a translucent sheet 12 having cavities 14 which are regularly formed and arranged, color balls 16 housed in the cavities 14, each having two surfaces with different optical characteristics and electrification characteristics from each other and rotatable by an electric effect, an insulating liquid 18 filling the space between the inner wall faces of the cavities 14 and the color balls 16, and polymer gel particles 26 dispersed in the insulating liquid 18.



LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's

(19)日本国特許庁（ＪＰ）　(12)公開特許公報（Ａ）　(11)特許出願公開番号
特開2002－287175
（P2002－287175A）
(43)公開日　平成14年10月３日(2002.10.3)

(51)Int.Cl.⁷	識別記号	ＦＩ	ﾃｰﾏｺｰﾄﾞ(参考)
Ｇ０２Ｆ　1/167		Ｇ０２Ｆ　1/167	

審査請求　未請求　請求項の数５　ＯＬ　（全７頁）

(21)出願番号　特願2001－84897(P2001－84897)

(22)出願日　平成13年３月23日(2001.3.23)

(71)出願人　000006079
ミノルタ株式会社
大阪府大阪市中央区安土町二丁目３番13号
大阪国際ビル

(72)発明者　坂本　和洋
大阪府大阪市中央区安土町二丁目３番13号
大阪国際ビル　ミノルタ株式会社内

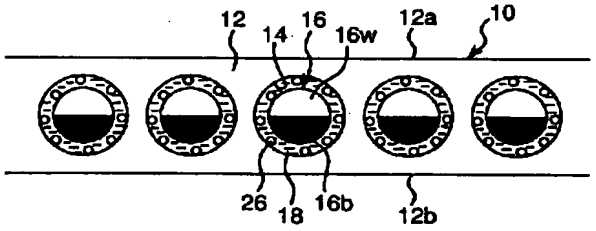
(72)発明者　中根　良樹
大阪府大阪市中央区安土町二丁目３番13号
大阪国際ビル　ミノルタ株式会社内

(74)代理人　100062144
弁理士　青山　葆　（外３名）

最終頁に続く

(54)【発明の名称】　ツイスティングボールディスプレイシート

(57)【要約】
【課題】　画像書き込み後に偶発的な摩擦帯電や保持電荷の消失があっても、画像を安定して保持できるツイスティングボールディスプレイシートを提供する。
【解決手段】　本発明にかかるツイスティングボールディスプレイシート１０は、規則的に配列形成されたキャビティ１４を有する透光性シート１２と、キャビティ１４内に収容され、光学特性と帯電特性が異なる２つの表面を有し、電気的作用により回転可能な着色ボール１６と、キャビティ１４の内壁面と着色ボール１６との間に充填された絶縁性液体１８と、絶縁性液体１８中に分散された高分子ゲル粒子２６とを備えている。



【特許請求の範囲】

【請求項１】　規則的に配列形成されたキャビティを有する透光性シートと、

前記キャビティ内に収容され、光学特性と帯電特性が異なる少なくとも２つの表面を有し、電気的作用により回転可能な着色ボールと、

前記キャビティの内壁面と前記着色ボールとの間に充填された絶縁性液体と、

前記絶縁性液体中に分散された可逆的体積変化物質と、を備えたツイスティングボールディスプレイシート。

【請求項２】　規則的に配列形成されたキャビティを有する透光性シートと、

前記キャビティ内に収容され、光学特性と帯電特性が異なる少なくとも２つの表面を有し、電気的作用により回転可能な着色ボールと、

前記キャビティの内壁面と前記着色ボールとの間に充填された絶縁性液体と、を備え、前記着色ボールの全部または一部が可逆的体積変化物質からなることを特徴とするツイスティングボールディスプレイシート。

【請求項３】　前記可逆的体積変化物質は熱により体積変化を生じることを特徴とする請求項１または２に記載のツイスティングボールディスプレイシート。

【請求項４】　規則的に配列形成されたキャビティを有する透光性シートと、

前記キャビティ内に収容され、光学特性と帯電特性が異なる少なくとも２つの表面を有し、電気的作用により回転可能な着色ボールと、

前記キャビティの内壁面と前記着色ボールとの間に充填された絶縁性液体と、を備え、前記キャビティの内壁の少なくとも一部が可逆的体積変化物質で形成されていることを特徴とするツイスティングボールディスプレイシート。

【請求項５】　前記可逆的体積変化物質は熱または光により体積変化を生じることを特徴とする請求項４に記載のツイスティングボールディスプレイシート。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、絶縁性液体を充填したキャビティ内に部分的に異なる帯電特性を有する着色ボールを収容しており、この着色ボールを電気的作用によって回転させることにより画像（テキストを含む）を表示するツイスティングボールディスプレイシートに関する。

【０００２】

【従来の技術】従来、図１２に示すような部分断面を有するツイスティングボールディスプレイシート（以下、単に「シート」という場合がある）１１が知られている。このシート１１は、例えばエラストマのような材料から作られた透光性シート１２からなる。透光性シート１２内には、内部が球状である多数のキャビティ１４が

規則的（例えば格子状）に配列形成されている。キャビティ１４には、着色ボール１６が収容されている。キャビティ１４は、着色ボール１６のサイズよりも若干大きく形成されている。キャビティ１４の内壁面と着色ボール１６との間には、絶縁性液体１８が充填されている。このようなキャビティ１４の一つ一つがシート１１において画素を構成する。

【０００３】着色ボール１６は、光学特性が異なる２つの表面を有する。具体的には、着色ボール１６は、片側に白色半球体１６ｗを有し、もう片側に黒色半球体を有する。これらの色は、両方の半球体の各表面に塗料等を塗り分けるか、または一方の半球体の表面だけに塗料等を塗布することにより着色されてもよいし、各半球体を構成する材料に顔料等の色素をそれぞれ含有させることにより着色されたものでもよい。また、着色ボール１６は、直径が数十μｍ以下、好ましくは１０ないし２０μｍ程度の大きさである。

【０００４】また、着色ボール１６は、帯電特性が異なる２つの表面、すなわち白色半球体表面と黒色半球体表面を有する。これにより、着色ボール１６の内部には双極子モーメントが生じている。このように双極子モーメントを生じさせる方法としては、各半球体１６ｗ，１６ｂの表面を異なるゼータ電位を有する膜でそれぞれ被覆する、ボールを強誘電体材料で形成して各半球体対向方向に分極させる、各半球体１６ｗ，１６ｂを異なる仕事関数を有する材料でそれぞれ形成する等がある。このように双極子モーメントが生じている着色ボール１６に所定の電界をかけると、着色ボール１６は回転することになる。ここでは、白色半球体１６ｗが正（＋）の電荷を有し、黒色半球体１６ｂが負（－）の電荷を有するものと仮定する。

【０００５】なお、このようなシート１１や着色ボール１６の製造方法は、例えば米国特許第４，１２６，８５４号、特開平１０－２１４０５０号、特開平１０－３３３６０８号などに開示されていて公知のものである。

【０００６】上述した構成を有するシート１１では、画像形成前に所定の電界をかけることにより、図１２に示すように、すべての着色ボール１６がそれぞれの白色半球体１６ｗを同じ方向に向けた状態に回転してそろっている。これにより、シート１１を上方（Ｘ方向、図１３においても同じ）から見ると、シート全体が白色に見える。この状態にあるシート１１に対して、図１３に示すように、シート１１を挟んで配置した外部電極２０，２２により所望のキャビティ１４に電界２４をかけると、負極性帯電した黒色半球体１６ｂはプラス電圧が印加された電極２０に引き付けられるとともに、正極性帯電した白色半球体１６ｗはマイナス電圧が印加された電極２２に引き付けられる。これにより、着色ボール１６は、黒色半球体１６ｂが電極２０に向いた状態に回転し、シート１１を上方から見ると黒色ドットに見える。このよ

うにして多数の着色ボール１６を選択的に回転させることによりシート１１に所望の画像を表示することができる。

【０００７】このようにして表示された画像は、外部電極２０，２２によってシート１１の表面に付与された保持電荷により着色ボール１６が回転しないように維持されることで保持される。

【０００８】

【発明が解決しようとする課題】しかしながら、上記のように画像が表示されたシート１１では、手でこするなどによる偶発的な摩擦帯電や保持電荷の消失があった場合に画像表示部や非画像表示部の着色ボールが回転してしまうことがあり、画像を安定して保持できないという問題があった。

【０００９】

【課題を解決するための手段】そこで、前記問題を解決するために本発明の第１のツイスティングボールディスプレイシートは、規則的に配列形成されたキャビティを有する透光性シートと、前記キャビティ内に収容され、光学特性と帯電特性が異なる少なくとも２つの表面を有し、電気的作用により回転可能な着色ボールと、前記キャビティの内壁面と前記着色ボールとの間に充填された絶縁性液体と、前記絶縁性液体中に分散された可逆的体積変化物質と、を備えたものである。

【００１０】また、本発明の第２のツイスティングボールディスプレイシートは、規則的に配列形成されたキャビティを有する透光性シートと、前記キャビティ内に収容され、光学特性と帯電特性が異なる少なくとも２つの表面を有し、電気的作用により回転可能な着色ボールと、前記キャビティの内壁面と前記着色ボールとの間に充填された絶縁性液体とを備え、前記着色ボールの全部または一部が可逆的体積変化物質からなることを特徴とするものである。

【００１１】前記本発明の第１および第２のツイスティングボールディスプレイシートでは、前記可逆的体積変化物質が熱により体積変化を生じるものであってもよい。

【００１２】また、本発明の第３のツイスティングボールディスプレイシートは、規則的に配列形成されたキャビティを有する透光性シートと、前記キャビティ内に収容され、光学特性と帯電特性が異なる少なくとも２つの表面を有し、電気的作用により回転可能な着色ボールと、前記キャビティの内壁面と前記着色ボールとの間に充填された絶縁性液体とを備え、前記キャビティの内壁の少なくとも一部が可逆的体積変化物質で形成されていることを特徴とするものである。

【００１３】本発明の第３のツイスティングボールディスプレイシートでは、前記可逆的体積変化物質が熱または光により体積変化を生じるものであってもよい。

【００１４】

【発明の効果】本発明の第１のツイスティングボールディスプレイシートでは、画像書き込み時には、着色ボールの周囲の絶縁性液体中に分散した可逆的体積変化物質を収縮させる。これにより、可逆的体積変化物質との摩擦抵抗が低減され、着色ボールは絶縁性液体中で回転可能な状態になる。一方、画像書き込み終了後には、前記可逆的体積変化物質を着色ボール表面およびキャビティ内壁面に接触した状態に膨張させる。その結果、画像を表示した状態に回転した着色ボールは、可逆性体積変化物質との摩擦抵抗が増大することにより回転が抑制され、その状態のままで保持される。このことは、非画像表示部の着色ボールについても同様である。したがって、本発明の第１のツイスティングボールディスプレイシートによれば、画像書き込み後に偶発的な摩擦帯電や保持電荷の消失があっても着色ボールが回転することがなく、画像を安定して保持することができる。

【００１５】本発明の第２のツイスティングボールディスプレイシートでは、着色ボールの全部または一部が可逆的体積変化物質で構成されており、画像書き込み時には着色ボール自体を収縮させてキャビティ内壁面と非接触にすることにより絶縁性液体中で回転可能な状態にし、画像書き込み終了後には着色ボール自体を膨張させることでキャビティ内壁面に接触させて摩擦抵抗を増大させることによって回転を抑制する。したがって、本発明の第２のツイスティングボールディスプレイシートによってもまた、画像書き込み後に偶発的な帯電摩擦や保持電荷の消失があっても着色ボールが回転することがなく、画像を安定して保持することができる。

【００１６】本発明の第３のツイスティングボールディスプレイシートでは、キャビティ内壁の少なくとも一部が可逆的体積変化物質で構成されており、画像書き込み時には可逆性体積変化物質で構成された内壁を膨張または収縮させてキャビティ内壁面と非接触にすることにより着色ボールを絶縁性液体中で回転可能な状態にし、画像書き込み終了後には前記内壁部を収縮または膨張させることでキャビティ内壁面に接触させて摩擦抵抗を増大させることによって着色ボールの回転を抑制する。したがって、本発明の第２のツイスティングボールディスプレイシートによってもまた、画像書き込み後に偶発的な帯電摩擦や保持電荷の消失があっても着色ボールが回転することがなく、画像を安定して保持することができる。

【００１７】

【発明の実施の形態】以下、本発明の実施の形態について添付図面を参照して説明する。なお、前記従来技術の欄で説明したツイスティングボールディスプレイシート１１と共通する構成については同一符号を用いて説明する。

【００１８】図１は、第１実施形態のツイスティングボールディスプレイシート１０の部分断面を示す。このシ

ート１０は、実質的に透明でその硬度が後述する着色ボールよりも低く可逆的変形を起こす熱可塑性エラストマ(例えばスチレンーブタジエンースチレン（ＳＢＳ）)またはゴム材のような材料から作られた透光性シート１２からなる。透光性シート１２内には、内部が球状である多数のキャビティ１４が規則的（例えば格子状）に配列形成されている。キャビティ１４には、着色ボール１６が収容されている。キャビティ１４は、着色ボール１６のサイズよりも若干大きく形成されている。キャビティ１４の内壁面と着色ボール１６との間には、例えばシリコンオイルのような絶縁性液体１８が充填されている。絶縁性液体１８中には、可逆的体積変化物質である高分子ゲル粒子２６が分散されている。このようなキャビティ１４の一つ一つがシート１０において画素を構成する。

【００１９】着色ボール１６は、光学特性が異なる２つの表面を有する。具体的には、着色ボール１６は、片側に白色半球体１６ｗを有し、もう片側に黒色半球体を有する。これらの色は、白色半球体１６ｗの構成材料であるポリマに白色顔料粒子を含ませ、黒色半球体１６ｂの構成材料であるポリマに黒色顔料粒子を含ませることにより着色されている。着色ボール１６の構成材料としては、スチレン樹脂、スチレンーアクリレート樹脂、ナトリウムスルホン化ポリエステル、スチレンーメタクリレート樹脂、またはスチレンーメタクリレートーアクリル酸ターポリマなどが用いられる。また、着色ボール１６は、直径が数十μｍ以下、好ましくは１０ないし２０μｍ程度の大きさである。

【００２０】また、着色ボール１６は、帯電特性が異なる２つの表面、すなわち白色半球体表面と黒色半球体表面を有する。これにより、着色ボール１６の内部には双極子モーメントが生じている。このように双極子モーメントを生じさせる方法としては、各半球体１６ｗ，１６ｂの表面を異なるゼータ電位を有する膜でそれぞれ被覆する、ボールを強誘電体材料で形成して各半球体対向方向に分極させる、各半球体１６ｗ，１６ｂを異なる仕事関数を有する材料でそれぞれ形成する等がある。このように双極子モーメントが生じている着色ボール１６に所定の電界をかけると、着色ボール１６は回転することになる。ここでは、白色半球体１６ｗが正（＋）の電荷を有し、黒色半球体１６ｂが負（－）の電荷を有するものとする。

【００２１】高分子ゲル粒子２６は、熱を加えると絶縁性液体１８を脱して収縮する一方、常温に戻ると絶縁性液体１８を吸収して膨張するというように、可逆的に体積変化する性質を有する。このような性質を有する高分子ゲル材料としては、ＬＣＳＴ（下限臨界共融温度）をもつ高分子の架橋体が好ましい。具体的な化合物としては、ポリＮーイソプロピルアクリルアミドなどの［Ｎーアルキル置換（メタ）アクリルアミド］の架橋体やＮーアルキル置換（メタ）アクリルアミドと（メタ）アクリル酸およびその金属塩、または（メタ）アクリルアミド、または（メタ）アクリル酸アルキルエステルなどの２成分以上の共重合体の架橋体、ポリビニルメチルエーテルの架橋物、メチルセルロース、エチルセルロース、ヒドロキシプロピルセルロースなどのアルキル置換セルロース誘導体の架橋体などが挙げられる。

【００２２】続いて、以上の構成からなるシート１０の動作について説明する。シート１０は、画像形成前に所定の電界がかけられることにより、図１に示すように、すべての着色ボール１６がそれぞれの白色半球体１６ｗを同じ方向に向けた状態に回転してそろっている。これにより、シート１０をシート表面１２ａ側から見ると、シート全体が白色に見える。

【００２３】この状態にあるシート１０に対して、画像書き込み時には、図２に示すように、シート１０に熱を加えるとともに、シート１０を挟んで配置した外部電極２０，２２により所望のキャビティ１４に電界２４をかける。前記加熱によりキャビティ１４内の高分子ゲル粒子２６は絶縁性液体１８を脱して収縮する。これにより、高分子ゲル２６との摩擦抵抗が低減し、着色ボール１６は回転可能な状態になる。

【００２４】このように回転可能な状態になった着色ボール１６では、前記電界２４の作用により、負極性帯電した黒色半球体１６ｂはプラス電圧が印加された電極２０に引き付けられるとともに、正極性帯電した白色半球体１６ｗはマイナス電圧が印加された電極２２に引き付けられる。その結果、着色ボール１６は、黒色半球体１６ｂが電極２０に対向した状態に回転し、シート表面１２ａ側から見ると黒色ドットに見える。電界２４によって回転させられた着色ボール１６は、外部電極２０，２２によってシート１０の表面１２ａおよび裏面１２ｂに付与された保持電荷（＋および－で図示）により回転が抑制されて保持される。このようにして多数の着色ボール１６を選択的に回転させることにより、シート１０に所望の画像を書き込むことができる。

【００２５】このようにして画像が書き込まれた後、シート１０は一般に使用される環境（常温）に戻される。すると、高分子ゲル粒子２６は、図３に示すように、絶縁性液体１８を吸収して膨張し、着色ボール１６表面およびキャビティ１４内壁面と接触した状態になる。これにより、着色ボール１６は、高分子ゲル粒子２６との摩擦抵抗が増大することで回転が抑制され、そのままの状態で保持されることになる。この場合の着色ボール１６の保持力は、保持電荷によるものだけの場合に比べて強力である。また、電界が印加されないことで回転しなかった非画像部の着色ボール１６、すなわち白色半球体１６ｗをシート表面１２ａ側に向けた状態のままの着色ボール１６についても、膨張した高分子ゲル粒子２６によって回転が抑制されて保持される。したがって、シート

１０によれば、画像書き込み後に偶発的な摩擦帯電や保持電荷の消失があっても着色ボール１６が回転することなく、画像を安定して保持することができる。

【００２６】次に、第２実施形態のツイスティングボールディスプレイシート１０ａについて説明する。このシート１０ａにおいて前記第１実施形態のシート１０と異なる点は、図４に示すように、絶縁性液体１８中に高分子ゲル粒子２６が分散されておらず、着色ボール１６全体が、熱で収縮する上述したような高分子ゲル材料で構成されている。

【００２７】このシート１０ａでは、画像書き込み時に加熱することにより、着色ボール１６自体が絶縁性液体１８を脱して収縮する。これにより、着色ボール１６は、キャビティ１４の内壁面と非接触状態になり、摩擦抵抗が大きく低減されて回転可能な状態なる。この状態で、第１実施形態のシート１０について説明したのと同様に、所望のキャビティ１４に適当な電界をかけることにより、着色ボール１６が回転して画像の書き込みが行われる。画像書き込み終了後、シート１０ａが一般に使用される環境（常温）に戻されると、図５に示すように、着色ボール１６自体が絶縁性液体１８を吸収して膨張し、キャビティ１４の内壁面に接触した状態になる。これにより、摩擦抵抗が大幅に増大することで、着色ボール１６の回転が抑制され、そのままの状態に保持されることになる。したがって、シート１０ａによってもまた、画像書き込み後の偶発的な摩擦帯電や保持電荷の消失があっても着色ボール１６が回転することがなく、画像を安定して保持することができる。

【００２８】なお、前記シート１０ａでは着色ボール１６の全部を高分子ゲル材料で構成したが、着色ボール１６の一部を高分子ゲル材料で構成してもよい。例えば、着色ボール１６のうち黒色半球体１６ｂだけを高分子ゲル材料で構成した場合、常温時には黒色半球体１６ｂが絶縁性液体１８を吸収して膨張する。これにより、図６に示すように、着色ボール１６が卵のような形になってその両端部がキャビティ１４の内壁面に接触し、着色ボール１６の回転が抑制される。

【００２９】次に、第３実施形態のツイスティングボールディスプレイシート１０ｂについて図７，８を参照して説明する。このシート１０ｂは、図７に示すように、第１シート１２ｃと第２シート１２ｄとを例えば超音波溶着などの方法でシート周辺部（図示せず）だけを互いに接着することにより形成されている。第１シート１２ｃには、キャビティ１４の内壁となる仕切壁１３ａが形成されている。この仕切壁１３には隙間が形成されている。この隙間に高分子ゲル２８が充填されている。高分子ゲル２８を両側から挟む仕切壁１３は、比較的柔らかい材料であって後述するように伸縮する高分子ゲル２８をサポートする役割をも果たす。キャビティ１４には、着色ボール１６が収容されるとともに絶縁性液体１８が充填されている。なお、上記のような仕切壁１３を有する第１シート１２ｃは、フォトリソグラフィやエッチングなどを用いた精密微細加工により形成可能である。

【００３０】本実施形態の高分子ゲル２８は、熱を加えると絶縁性液体１８を吸収して膨張する一方、常温に戻ると絶縁性液体１８を脱して収縮するというように、可逆的に体積変化する性質を有する。この高分子ゲル２８としては、互いに水素結合する２成分の高分子ゲルのＩＰＮ（相互侵入網目構造体）などが好ましい。具体的な化合物としては、ポリ（メタ）アクリルアミドの架橋体とポリ（メタ）アクリル酸の架橋体からなるＩＰＮ体およびその部分中和体（アクリル酸単位を部分的に金属塩化したもの）、ポリ（メタ）アクリルアミドを主成分とする共重合体の架橋体とポリ（メタ）アクリル酸の架橋体からなるＩＰＮ体およびその部分中和体などが挙げられる。

【００３１】上記構造を有するシート１０ｂでは、画像が書き込まれる前の常温時には、着色ボール１６は仕切壁１３と非接触であるが第１シート１２ｃと第２シート１２ｄとに挟まれて保持されている。また、画像書き込み前には、所定の電界を印加することにより、すべての着色ボール１６が白色半球体１６ｗを第１シート１２ｃ側に向けた状態に揃えられている。

【００３２】このようなシート１０ｂに画像の書き込みを行うときには、シート１０ｂに熱を加える。これにより、図８に示すように、高分子ゲル２８が絶縁性液体１８を吸収して膨張し、キャビティ１４がシート厚み方向に拡張される。その結果、着色ボール１６は、第１シート１２ｃおよび第２シート１２ｄと非接触となって摩擦抵抗が大きく低減することにより、回転可能な状態になる。この状態で、第１実施形態のシート１０で説明したのと同じように、所望のキャビティ１４に電界をかけて着色ボール１６を回転させて画像の書き込みを行う。画像書き込み終了後、シート１０ｂが一般に使用される環境（常温）に戻されると、高分子ゲル２８は絶縁性液体１８を脱して収縮し、図７に示す状態に戻る。これにより、回転して画像を表示する着色ボール１６および回転せずに白地を表示したままの着色ボール１６のいずれもが第１シート１２ｃと第２シート１２ｄとに接触して摩擦抵抗が増大し、回転が抑制されて保持されることになる。したがって、本実施形態のシート１０ｂによってもまた、画像書き込み後に偶発的な摩擦帯電や保持電荷の消失があっても、画像を安定して保持することができる。

【００３３】なお、前記シート１０ｂでは仕切壁１３の隙間に高分子ゲル２８を充填するようにしたが、図９に示すようにキャビティ内壁である仕切壁１３自体の一部を高分子ゲル２８で構成してもよい。

【００３４】また、前記シート１０ｂでは仕切壁１３の隙間に充填することでキャビティ１４の内壁の一部を高

分子ゲル２８で構成するようにしたが、図１０に示すように、仕切壁１３以外のキャビティ１４の内壁を高分子ゲル２８，２８（いずれか一方だけ設けてもよい）で構成してもよい。この場合、高分子ゲル２８は、第１実施形態のシート１０における高分子ゲル粒子２６と同じ性質（すなわち熱により収縮）を有しており、常温時にはそれぞれ膨張した高分子ゲル２８，２８間に挟むことによって着色ボール１６を保持する。さらに、図１１に示すように、キャビティ１４の内壁の全部を高分子ゲル２８で構成してもよい。この場合もまた、高分子ゲル２８は、第１実施形態のシート１０における高分子ゲル粒子２６と同じ性質を有している。したがって、高分子ゲル２８は、加熱により収縮して図１１に示すように着色ボール１６を回転可能な状態にし、常温時には膨張してボール周囲に接触することにより着色ボール１６を保持することになる。

【００３５】ところで、前記シート１０ｂでは、熱により体積変化を生じる高分子ゲルを用いたが、これに代えて光により体積変化を生じる高分子ゲルを用いてもよい。このような高分子ゲルの化合物としては、例えばポリビニルメチルエーテル、トリフェニルメタンのロイコ体、ロイコヒドロキシドが側鎖に一部導入されたポリスチレン、ポリ（Ｎ、Ｎ－ジメチルアクリルアミド）、ポリアクリルアミドなどがある。ポリビニルメチルエーテルを用いた場合、これは赤外線を照射すると絶縁性液体１８を吸収して膨張するため、赤外線を照射した状態で画像書き込みを行うことで、前記シート１０ｂと同様の効果を得ることができる。

【００３６】以上の実施形態およびその変形例では、光学特性と帯電特性が異なる２つの表面を有する着色ボール（すなわち白黒着色で正負帯電のボール）１６を用いたが、本発明のツイスティングボールディスプレイシートでは光学特性と帯電特性が異なる３つ以上の表面を有する着色ボールを用いてもよい。

【図面の簡単な説明】

【図１】　第１実施形態のツイスティングボールディスプレイシートの部分断面図。

【図２】　図１のシートの所望のキャビティに電界をかけて着色ボールを回転させるときの状態を示す図。

【図３】　図１のシートにおいて、着色ボールが高分子ゲル粒子により保持される状態を示す図。

【図４】　第２実施形態のツイスティングボールディスプレイシートの部分断面図。

【図５】　図４のシートにおいてキャビティ内で着色ボールが保持される状態を示す図。

【図６】　第２実施形態の変形例において、キャビティ内で着色ボールが保持される状態を示す図。

【図７】　第２実施形態のツイスティングボールディスプレイシートの部分断面図。

【図８】　図７のシートにおいて、高分子ゲルが膨張した状態を示す図。

【図９】　第３実施形態の変形例を示す図。

【図１０】　第３実施形態の別の変形例を示す図。

【図１１】　第３実施形態のさらに別の変形例を示す図。

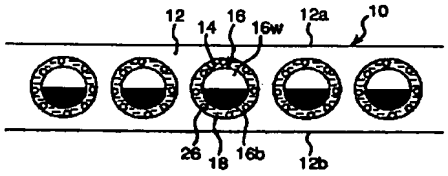
【図１２】　従来のツイスティングボールディスプレイシートの部分断面図。

【図１３】　図１２のシートの所望のキャビティに電界をかけて着色ボールを回転させるときの状態を示す図

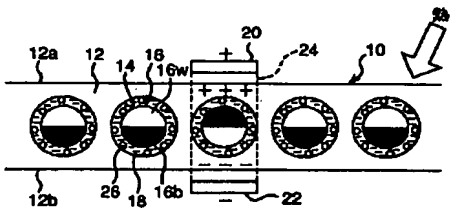
【符号の説明】

１０，１０ａ，１０ｂ…ツイスティングボールディスプレイシート、１２…透光性シート、１４…キャビティ、１６…着色ボール、１６ｂ…黒色半球体、１６ｗ…白色半球体、１８…絶縁性液体、２０，２２…外部電極、２４…電界、２６…高分子ゲル粒子（可逆的体積変化物質）、２８…高分子ゲル（可逆的体積変化物質）。

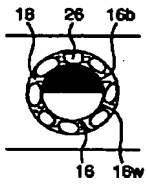
【図１】



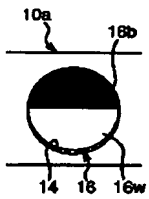
【図２】



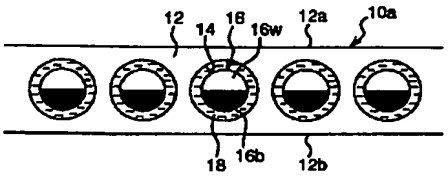
【図３】



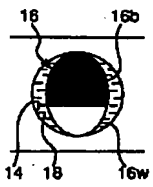
【図５】



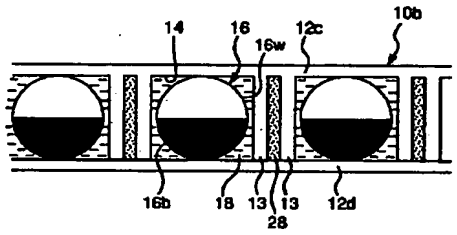
【図４】



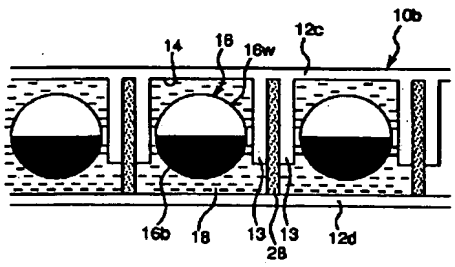
【図６】



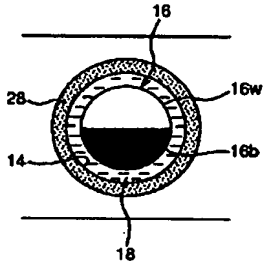
【図７】



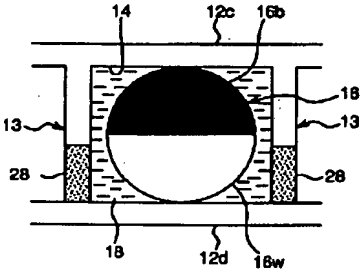
【図８】



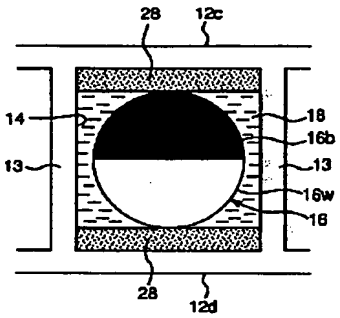
【図１１】



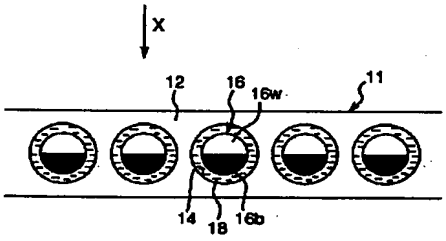
【図９】



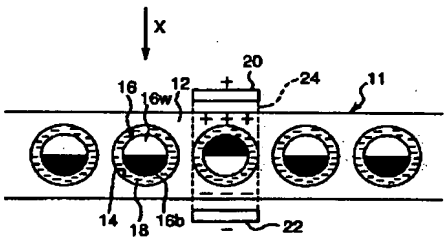
【図１０】



【図１２】



【図１３】



フロントページの続き

(72)発明者　山木　秀郎
大阪府大阪市中央区安土町二丁目３番13号
大阪国際ビル　ミノルタ株式会社内

(72)発明者　吉田　成隆
大阪府大阪市中央区安土町二丁目３番13号
大阪国際ビル　ミノルタ株式会社内

(72)発明者　松浦　晋也
大阪府大阪市中央区安土町二丁目３番13号
大阪国際ビル　ミノルタ株式会社内

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] The TSUISUTINGU ball display sheet equipped with the insulating liquid with which is held the translucency sheet which has the cavity by which array formation was carried out regularly, and in said cavity, and has at least two front faces where an optical property differs from an electrification property, and the electric action was filled up between the pivotable coloring ball, and the internal surface of said cavity and said coloring ball, and the reversible volume change matter distributed in said insulating liquid.
[Claim 2] The TSUISUTINGU ball display sheet characterized by to hold the translucency sheet which has the cavity by which array formation was carried out regularly, and in said cavity, to have at least two front faces where an optical property differs from an electrification property, to have the insulating liquid with which the electric action was filled up between the pivotable coloring ball, and the internal surface of said cavity and said coloring ball, and for all or some of said coloring ball to consist of reversible volume change matter.
[Claim 3] Said reversible volume change matter is a TSUISUTINGU ball display sheet according to claim 1 or 2 characterized by producing a volume change with heat.
[Claim 4] It holds the translucency sheet which has the cavity by which array formation was carried out regularly, and in said cavity, and has at least two front faces where an optical property differs from an electrification property. By the electric action A pivotable coloring ball, The TSUISUTINGU ball display sheet characterized by having the insulating liquid with which it filled up between the internal surface of said cavity, and said coloring ball, and forming some walls [at least] of said cavity by the reversible volume change matter.
[Claim 5] Said reversible volume change matter is a TSUISUTINGU ball display sheet according to claim 4 characterized by producing a volume change by heat or light.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention has held the coloring ball which has a partially different electrification property in the cavity filled up with the insulating liquid, and relates to the TSUISUTINGU ball display sheet which displays an image (a text is included) by rotating this coloring ball by the electric action.
[0002]
[Description of the Prior Art] Conventionally, the TSUISUTINGU ball display sheet (it may only be hereafter called a "sheet") 11 which has a partial cross section as shown in drawing 12 is known. This sheet 11 consists of a translucency sheet 12 made from an ingredient like an elastomer. the cavity 14 of a large number with the interior spherical in the translucency sheet 12 -- being regular (the shape of for example, a grid) -- array formation is carried out. The coloring ball 16 is held in the cavity 14. The cavity 14 is greatly formed a little rather than the size of the coloring ball 16. It fills up with the insulating liquid 18 between the internal surface of a cavity 14, and the coloring ball 16. Each of such cavities 14 constitutes a pixel in a sheet 11.
[0003] The coloring ball 16 has two front faces where optical properties differ. The coloring ball 16 has white hemisphere 16w in one side, and, specifically, already has a black hemisphere in one side. It could be colored by distinguishing a coating etc. by different color with on each front face of both hemispheres, or applying a coating etc. only to the front face of one hemisphere, and these colors could be colored by making the ingredient which constitutes each hemisphere contain coloring matter, such as a pigment, respectively. Moreover, the diameter dozens of micrometers or less of the coloring ball 16 is about 20 micrometers in 10 thru/or magnitude preferably.
[0004] Moreover, the coloring ball 16 has the front face which is two from which an electrification property differs, i.e., a white hemisphere front face, and a black hemisphere front face. Thereby, the dipole moment has arisen inside the coloring ball 16. Thus, forming, respectively with the ingredient which is covered with the film which has F-potential which is different in the front face of each hemispheres 16w and 16b as an approach of producing the dipole moment, respectively, which forms a ball with a ferroelectric ingredient and is made to carry out polarization in each hemisphere opposite direction and which has a work function which is different in each hemispheres 16w and 16b etc. occurs. Thus, when predetermined electric field are applied to the coloring ball 16 which the dipole moment has produced, the coloring ball 16 will rotate. Here, it is assumed that it is that in which white hemisphere 16w has the charge of forward (+), and black hemisphere 16b has the charge of negative (-).
[0005] In addition, such a manufacture approach of a sheet 11 or the coloring ball 16 is indicated by U.S. Pat. No. 4,126,854, JP,10-214050,A, JP,10-333608,A, etc., and is well-known.
[0006] With the sheet 11 which has the configuration mentioned above, by applying predetermined electric field before image formation, as shown in drawing 12 , all the coloring balls 16 rotate and are equal to the condition of having turned each white hemisphere 16w in the same direction. Thereby, when a sheet 11 is seen from the upper part (it is the same also in the direction of X, and drawing 13), the whole sheet is visible to white. If electric field 24 are applied

to the desired cavity 14 to the sheet 11 in this condition with the external electrodes 20 and 22 arranged on both sides of a sheet 11 as shown in drawing 13 , while being drawn to the electrode 20 with which positive voltage was impressed by black hemisphere 16b which carried out negative polarity electrification, it is drawn to the electrode 22 with which the minus electrical potential difference was impressed by white hemisphere 16w which carried out straight polarity electrification. Thereby, the coloring ball 16 is visible to a black dot, when black hemisphere 16b rotates in the condition of having turned to the electrode 20 and looks at a sheet 11 from the upper part. Thus, a desired image can be displayed on a sheet 11 by rotating many coloring balls 16 alternatively.

[0007] Thus, the displayed image is held by being maintained so that the coloring ball 16 may not rotate with the maintenance charge given to the front face of a sheet 11 with the external electrodes 20 and 22.

[0008]

[Problem(s) to be Solved by the Invention] However, with the sheet 11 as which the image was displayed as mentioned above, when there was disappearance of the accidental frictional electrification by rubbing by hand etc. or a maintenance charge, the coloring ball of the image display section or the non-image display section may rotate, and there was a problem that it was stabilized and an image could not be held.

[0009]

[Means for Solving the Problem] In order to solve said problem then, the 1st TSUISUTINGU ball display sheet of this invention It holds the translucency sheet which has the cavity by which array formation was carried out regularly, and in said cavity, and has at least two front faces where an optical property differs from an electrification property. By the electric action A pivotable coloring ball, It has the insulating liquid with which it filled up between the internal surface of said cavity, and said coloring ball, and the reversible volume change matter distributed in said insulating liquid.

[0010] Moreover, the 2nd TSUISUTINGU ball display sheet of this invention It holds the translucency sheet which has the cavity by which array formation was carried out regularly, and in said cavity, and has at least two front faces where an optical property differs from an electrification property. By the electric action A pivotable coloring ball, It has the insulating liquid with which it filled up between the internal surface of said cavity, and said coloring ball, and is characterized by said all or some of coloring ball consisting of reversible volume change matter.

[0011] With the 1st [of said this invention], and 2nd TSUISUTINGU ball display sheets, said reversible volume change matter may produce a volume change with heat.

[0012] Moreover, the 3rd TSUISUTINGU ball display sheet of this invention It holds the translucency sheet which has the cavity by which array formation was carried out regularly, and in said cavity, and has at least two front faces where an optical property differs from an electrification property. By the electric action A pivotable coloring ball, It has the insulating liquid with which it filled up between the internal surface of said cavity, and said coloring ball, and is characterized by forming some walls [at least] of said cavity by the reversible volume change matter.

[0013] With the 3rd TSUISUTINGU ball display sheet of this invention, said reversible volume change matter may produce a volume change by heat or light.

[0014]

[Effect of the Invention] With the 1st TSUISUTINGU ball display sheet of this invention, the reversible volume change matter distributed in the insulating liquid around a coloring ball is shrunk at the time of image writing. Thereby, frictional resistance with the reversible volume change matter is reduced, and a coloring ball will be in a pivotable condition in an insulating liquid. On the other hand, after image write-in termination, said reversible volume change matter is expanded in the condition of having contacted the coloring ball front face and the cavity internal surface. Consequently, when frictional resistance with the reversibility volume change matter increases, rotation is controlled, and the coloring ball which rotated in the condition of having displayed the image is held while it has been in the condition. This is the same also about the coloring ball of the non-image display section. Therefore, according to the 1st TSUISUTINGU ball

display sheet of this invention, even if disappearance of accidental frictional electrification or a maintenance charge is after image writing, a coloring ball does not rotate, it is stabilized and an image can be held.

[0015] With the 2nd TSUISUTINGU ball display sheet of this invention, all or some of coloring ball consists of reversible volume change matter, by shrinking the coloring ball itself at the time of image writing, and making it a cavity internal surface and non-contact, it changes into a pivotable condition in an insulating liquid, and rotation is controlled by making a cavity internal surface contact by expanding the coloring ball itself after image write-in termination, and increasing frictional resistance. Therefore, even if accidental electrification friction and disappearance of a maintenance charge are after image writing also with the 2nd TSUISUTINGU ball display sheet of this invention, a coloring ball does not rotate, it is stabilized and an image can be held.

[0016] With the 3rd TSUISUTINGU ball display sheet of this invention Some cavity walls [at least] consist of reversible volume change matter. A coloring ball is changed into a pivotable condition in an insulating liquid by expanding or shrinking the wall which consisted of reversibility volume change matter at the time of image writing, and making it a cavity internal surface and non-contact. Rotation of a coloring ball is controlled by making a cavity internal surface contact by contracting or expanding said wall section after image write-in termination, and increasing frictional resistance. Therefore, even if accidental electrification friction and disappearance of a maintenance charge are after image writing also with the 2nd TSUISUTINGU ball display sheet of this invention, a coloring ball does not rotate, it is stabilized and an image can be held.

[0017]

[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained with reference to an accompanying drawing. In addition, the configuration which is common on the TSUISUTINGU ball display sheet 11 explained in the column of said conventional technique is explained using the same sign.

[0018] Drawing 1 shows the partial cross section of the TSUISUTINGU ball display sheet 10 of the 1st operation gestalt. This sheet 10 consists of a translucency sheet 12 made from an ingredient like the thermoplastic elastomer (for example, styrene-styrene butadiene rubber (SBS)) which causes reversible deformation lower [it is substantially transparent and] than the coloring ball which that degree of hardness mentions later, or rubber material. the cavity 14 of a large number with the interior spherical in the translucency sheet 12 -- being regular (the shape of for example, a grid) -- array formation is carried out. The coloring ball 16 is held in the cavity 14. The cavity 14 is greatly formed a little rather than the size of the coloring ball 16. It fills up with an insulating liquid 18 like a silicone oil between the internal surface of a cavity 14, and the coloring ball 16. In the insulating liquid 18, the polymer gel particle 26 which is the reversible volume change matter is distributed. Each of such cavities 14 constitutes a pixel in a sheet 10.

[0019] The coloring ball 16 has two front faces where optical properties differ. The coloring ball 16 has white hemisphere 16w in one side, and, specifically, already has a black hemisphere in one side. These colors are colored by including a white-pigments particle in the polymer which is the component of white hemisphere 16w, and including a black pigment particle in the polymer which is the component of black hemisphere 16b. As a component of the coloring ball 16, styrene resin, styrene-acrylate resin, sodium sulfonation polyester, styrene-methacrylate resin, or a styrene-methacrylate-acrylic-acid terpolymer is used. Moreover, the diameter dozens of micrometers or less of the coloring ball 16 is about 20 micrometers in 10 thru/or magnitude preferably.

[0020] Moreover, the coloring ball 16 has the front face which is two from which an electrification property differs, i.e., a white hemisphere front face, and a black hemisphere front face. Thereby, the dipole moment has arisen inside the coloring ball 16. Thus, forming, respectively with the ingredient which is covered with the film which has F-potential which is different in the front face of each hemispheres 16w and 16b as an approach of producing the dipole moment, respectively, which forms a ball with a ferroelectric ingredient and is made to carry out polarization in each hemisphere opposite direction and which has a work function which is different in each hemispheres 16w and 16b etc. occurs. Thus, when predetermined electric field are applied to the coloring ball 16 which the dipole moment has produced, the coloring ball 16 will rotate. Here, white hemisphere 16w shall have the charge of forward (+), and black

hemisphere 16b shall have the charge of negative (-).
[0021] The polymer gel particle 26 has the property which carries out a volume change reversibly as the insulating liquid 18 will be absorbed and it will expand, if it returns to ordinary temperature while escaping from the insulating liquid 18 and contracting, if heat is applied. As a polymer gel ingredient which has such a property, the bridge formation object of a macromolecule with LCST (minimum criticality eutectic temperature) is desirable. As a concrete compound, the bridge formation object of alkylation cellulosics, such as a bridge formation object of copolymers of two or more components, such as a bridge formation object of [N-alkylation (meta) acrylamides], such as Pori N-isopropyl acrylamide, N-alkylation (meta) acrylamide and an acrylic acid (meta) and its metal salt, acrylamide, or (meta) acrylic-acid alkyl ester, a bridge formation object of polyvinyl methyl ether, methyl cellulose, ethyl cellulose, and hydroxypropylcellulose, etc. is mentioned.
[0022] Then, actuation of the sheet 10 which consists of the above configuration is explained. By applying predetermined electric field before image formation, the sheet 10 rotates and is equal to the condition that all the coloring balls 16 turned each white hemisphere 16w in the same direction, as shown in drawing 1 . Thereby, when a sheet 10 is seen from the sheet surface 12a side, the whole sheet is visible to white.
[0023] As shown in drawing 2 to the sheet 10 in this condition at the time of image writing, while applying heat to a sheet 10, electric field 24 are applied to the desired cavity 14 with the external electrodes 20 and 22 arranged on both sides of a sheet 10. With said heating, the polymer gel particle 26 in a cavity 14 escapes from the insulating liquid 18, and contracts. Thereby, frictional resistance with polymer gel 26 decreases, and the coloring ball 16 will be in a pivotable condition.
[0024] Thus, with the coloring ball 16 which changed into the pivotable condition, while being drawn according to an operation of said electric field 24 to the electrode 20 with which positive voltage was impressed by black hemisphere 16b which carried out negative polarity electrification, it is drawn to the electrode 22 with which the minus electrical potential difference was impressed by white hemisphere 16w which carried out straight polarity electrification. Consequently, the coloring ball 16 is visible to a black dot, when black hemisphere 16b rotates in the condition of having countered the electrode 20 and sees from the sheet surface 12a side. Rotation is controlled with the maintenance charge (it illustrates by + and -) given to surface 12a and rear-face 12b of a sheet 10 with the external electrodes 20 and 22, and the coloring ball 16 rotated by electric field 24 is held. Thus, by rotating many coloring balls 16 alternatively, a desired image can be written in a sheet 10.
[0025] Thus, after an image is written in, a sheet 10 is returned to the environment (ordinary temperature) generally used. Then, as shown in drawing 3 , absorb the insulating liquid 18, the polymer gel particle 26 expands, and coloring ball 16 front face and cavity 14 internal surface will be contacted it. By this, rotation will be controlled because frictional resistance with the polymer gel particle 26 increases, and the coloring ball 16 will be held in the condition as it is. The holding power of the coloring ball 16 in this case is powerful compared with the case of what is depended on a maintenance charge. Moreover, rotation is controlled and held about the coloring ball 16 16 of the non-image section which did not rotate by electric field not being impressed, i.e., a coloring ball with the condition of having turned white hemisphere 16w to the sheet surface 12a side, by the polymer gel particle 26 which expanded. Therefore, without according to the sheet 10, the coloring ball 16 rotating, even if disappearance of accidental frictional electrification or a maintenance charge is after image writing, it is stabilized and an image can be held.
[0026] Next, TSUISUTINGU ball display sheet 10a of the 2nd operation gestalt is explained. The polymer gel particle 26 is not distributed in the insulating liquid 18, but a different point from the sheet 10 of said 1st operation gestalt in this sheet 10a consists of polymer gel ingredients which the coloring ball 16 whole contracts with heat and which were mentioned above, as shown in drawing 4 .
[0027] In this sheet 10a, by heating at the time of image writing, coloring ball 16 the very thing escapes from the insulating liquid 18, and contracts. by this, the coloring ball 16 will be in the

internal surface and non-contact condition of a cavity 14, and frictional resistance is reduced greatly, and pivotable -- a condition -- ** In this condition, the same with having explained the sheet 10 of the 1st operation gestalt, by applying the suitable electric field for the desired cavity 14, the coloring ball 16 rotates and the writing of an image is performed. After image write-in termination, if returned to the environment (ordinary temperature) where sheet 10a is generally used, as shown in drawing 5 , coloring ball 16 the very thing absorbs the insulating liquid 18, and expands, and the internal surface of a cavity 14 will be contacted. By this, rotation of the coloring ball 16 will be controlled and it will be held at a condition as it is because frictional resistance increases sharply. Therefore, even if there is disappearance of the accidental frictional electrification after image writing or a maintenance charge also by sheet 10a, the coloring ball 16 does not rotate, it is stabilized and an image can be held.

[0028] In addition, although the polymer gel ingredient constituted all of the coloring balls 16 from said sheet 10a, some coloring balls 16 may consist of polymer gel ingredients. For example, when only black hemisphere 16b is constituted from a polymer gel ingredient among the coloring balls 16, at the time of ordinary temperature, black hemisphere 16b absorbs the insulating liquid 18, and expands. Thereby, as shown in drawing 6 , the coloring ball 16 becomes a form like an egg, the both ends contact the internal surface of a cavity 14, and rotation of the coloring ball 16 is controlled.

[0029] Next, TSUISUTINGU ball display sheet 10b of the 3rd operation gestalt is explained with reference to drawing 7 and 8. This sheet 10b is formed by pasting up only a sheet periphery (not shown) for 1st sheet 12c and 2nd sheet 12d mutually by approaches, such as ultrasonic welding, as shown in drawing 7 . Bridge wall 13a used as the wall of a cavity 14 is formed in 1st sheet 12c. The clearance is formed in this bridge wall 13. This clearance is filled up with polymer gel 28. The bridge wall 13 which sandwiches polymer gel 28 from both sides also plays the role which supports the polymer gel 28 expanded and contracted so that it may be a comparatively soft ingredient and may mention later. The cavity 14 is filled up with the insulating liquid 18 while the coloring ball 16 is held. In addition, 1st sheet 12c which has the above bridge walls 13 can be formed by precision micro processing which used a photolithography, etching, etc.

[0030] The polymer gel 28 of this operation gestalt has the property which carries out a volume change reversibly as it will escape from the insulating liquid 18 and will contract, if it returns to ordinary temperature while absorbing the insulating liquid 18 and expanding, if heat is applied. As this polymer gel 28, IPN (mutual invasion network structure object) of the polymer gel of two components which carry out hydrogen bond etc. is desirable. As a concrete compound, the IPN object which consists of a bridge formation object of the Pori (meta) acrylamide and a bridge formation object of the Pori (meta) acrylic acid and its partial neutralization object (what carried out the metal chlorination of the acrylic-acid unit partially), the IPN object which consists of the bridge formation object of a copolymer and the bridge formation object of the Pori (meta) acrylic acid which use Pori (meta) acrylamide as a principal component, its partial neutralization object, etc. are mentioned.

[0031] In sheet 10b which has the above-mentioned structure, at the time of the ordinary temperature before an image is written in, although the coloring balls 16 are a bridge wall 13 and non-contact, it is inserted into 1st sheet 12c and 2nd sheet 12d, and they are held. Moreover, all the coloring balls 16 are arranged with the condition of having turned white hemisphere 16w to the 1st sheet 12c side, by impressing predetermined electric field before image writing.

[0032] When writing an image in such sheet 10b, heat is applied to sheet 10b. Thereby, as shown in drawing 8 , polymer gel 28 absorbs the insulating liquid 18, and expands, and a cavity 14 is extended in the sheet thickness direction. Consequently, the coloring ball 16 will be in a pivotable condition, when it becomes 1st sheet 12c and 2nd sheet 12d, and non-contact and frictional resistance decreases greatly. In this condition, as the sheet 10 of the 1st operation gestalt explained, electric field are applied to the desired cavity 14, the coloring ball 16 is rotated, and an image is written in. After image write-in termination, if returned to the environment (ordinary temperature) where sheet 10b is generally used, polymer gel 28 will escape from the insulating liquid 18, will contract, and will return to the condition which shows in drawing 7 . any of the having displayed white ground's, without [the coloring ball 16 which rotates and displays an

image by this, and] rotating coloring ball 16 -- although -- 1st sheet 12c and 2nd sheet 12d will be contacted, frictional resistance will increase, and rotation will be controlled and held. Therefore, also by sheet 10b of this operation gestalt, even if disappearance of accidental frictional electrification or a maintenance charge is after image writing, it is stabilized and an image can be held.

[0033] In addition, although polymer gel 28 was filled up with said sheet 10b into the clearance between bridge walls 13, a part of bridge wall 13 very thing which is a cavity wall as shown in drawing 9 may consist of polymer gels 28.

[0034] Moreover, although polymer gel 28 constituted some walls of a cavity 14 from filling up the clearance between bridge walls 13 with said sheet 10b, as shown in drawing 10 , the wall of cavities 14 other than bridge wall 13 may consist of polymer gels 28 and 28 (only either may be prepared). In this case, polymer gel 28 has the same property (namely, heat contraction) as the polymer gel particle 26 in the sheet 10 of the 1st operation gestalt, and holds the coloring ball 16 by inserting between the polymer gel 28 which expanded, respectively, and 28 at the time of ordinary temperature. Furthermore, as shown in drawing 11 , all of the walls of a cavity 14 may consist of polymer gels 28. Also in this case, polymer gel 28 has the same property as the polymer gel particle 26 in the sheet 10 of the 1st operation gestalt. Therefore, polymer gel 28 will change the coloring ball 16 into a pivotable condition, as it contracts with heating and is shown in drawing 11 , and it will hold the coloring ball 16 by expanding at the time of ordinary temperature and contacting the perimeter of a ball.

[0035] By the way, although the polymer gel which produces a volume change with heat was used in said sheet 10b, the polymer gel which replaces with this and produces a volume change by light may be used. As a compound of such polymer gel, there are the polystyrene and Pori (N and N-dimethyl acrylamide) where polyvinyl methyl ether, the leuco of a triphenylmethane color, and leuco hydroxide were introduced into the side chain in part, polyacrylamide, etc., for example. When polyvinyl methyl ether is used, since the insulating liquid 18 will be absorbed and this will expand if infrared radiation is irradiated, it can acquire the same effectiveness as said sheet 10b by performing image writing, where infrared radiation is irradiated.

[0036] Although the coloring ball (namely, ball of positive/negative electrification by monochrome coloring) 16 which has the front face which is two from which an optical property and an electrification property differ was used in the above operation gestalt and its modification, the coloring ball which has three or more front faces where an optical property differs from an electrification property may be used with the TSUISUTINGU ball display sheet of this invention.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

TECHNICAL FIELD

[Field of the Invention] This invention has held the coloring ball which has a partially different electrification property in the cavity filled up with the insulating liquid, and relates to the TSUISUTINGU ball display sheet which displays an image (a text is included) by rotating this coloring ball by the electric action.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

PRIOR ART

[Description of the Prior Art] Conventionally, the TSUISUTINGU ball display sheet (it may only be hereafter called a "sheet") 11 which has a partial cross section as shown in drawing 12 is known. This sheet 11 consists of a translucency sheet 12 made from an ingredient like an elastomer. the cavity 14 of a large number with the interior spherical in the translucency sheet 12 -- being regular (the shape of for example, a grid) -- array formation is carried out. The coloring ball 16 is held in the cavity 14. The cavity 14 is greatly formed a little rather than the size of the coloring ball 16. It fills up with the insulating liquid 18 between the internal surface of a cavity 14, and the coloring ball 16. Each of such cavities 14 constitutes a pixel in a sheet 11.
[0003] The coloring ball 16 has two front faces where optical properties differ. The coloring ball 16 has white hemisphere 16w in one side, and, specifically, already has a black hemisphere in one side. It could be colored by distinguishing a coating etc. by different color with on each front face of both hemispheres, or applying a coating etc. only to the front face of one hemisphere, and these colors could be colored by making the ingredient which constitutes each hemisphere contain coloring matter, such as a pigment, respectively. Moreover, the diameter dozens of micrometers or less of the coloring ball 16 is about 20 micrometers in 10 thru/or magnitude preferably.
[0004] Moreover, the coloring ball 16 has the front face which is two from which an electrification property differs, i.e., a white hemisphere front face, and a black hemisphere front face. Thereby, the dipole moment has arisen inside the coloring ball 16. Thus, forming, respectively with the ingredient which is covered with the film which has F-potential which is different in the front face of each hemispheres 16w and 16b as an approach of producing the dipole moment, respectively, which forms a ball with a ferroelectric ingredient and is made to carry out polarization in each hemisphere opposite direction and which has a work function which is different in each hemispheres 16w and 16b etc. occurs. Thus, when predetermined electric field are applied to the coloring ball 16 which the dipole moment has produced, the coloring ball 16 will rotate. Here, it is assumed that it is that in which white hemisphere 16w has the charge of forward (+), and black hemisphere 16b has the charge of negative (-).
[0005] In addition, such a manufacture approach of a sheet 11 or the coloring ball 16 is indicated by U.S. Pat. No. 4,126,854, JP,10-214050,A, JP,10-333608,A, etc., and is well-known.
[0006] With the sheet 11 which has the configuration mentioned above, by applying predetermined electric field before image formation, as shown in drawing 12 , all the coloring balls 16 rotate and are equal to the condition of having turned each white hemisphere 16w in the same direction. Thereby, when a sheet 11 is seen from the upper part (it is the same also in the direction of X, and drawing 13), the whole sheet is visible to white. If electric field 24 are applied to the desired cavity 14 to the sheet 11 in this condition with the external electrodes 20 and 22 arranged on both sides of a sheet 11 as shown in drawing 13 , while being drawn to the electrode 20 with which positive voltage was impressed by black hemisphere 16b which carried out negative polarity electrification, it is drawn to the electrode 22 with which the minus electrical potential difference was impressed by white hemisphere 16w which carried out straight polarity electrification. Thereby, the coloring ball 16 is visible to a black dot, when black hemisphere 16b rotates in the condition of having turned to the electrode 20 and looks at a sheet 11 from the

upper part. Thus, a desired image can be displayed on a sheet 11 by rotating many coloring balls 16 alternatively.

[0007] Thus, the displayed image is held by being maintained so that the coloring ball 16 may not rotate with the maintenance charge given to the front face of a sheet 11 with the external electrodes 20 and 22.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

EFFECT OF THE INVENTION

[Effect of the Invention] With the 1st TSUISUTINGU ball display sheet of this invention, the reversible volume change matter distributed in the insulating liquid around a coloring ball is shrunk at the time of image writing. Thereby, frictional resistance with the reversible volume change matter is reduced, and a coloring ball will be in a pivotable condition in an insulating liquid. On the other hand, after image write-in termination, said reversible volume change matter is expanded in the condition of having contacted the coloring ball front face and the cavity internal surface. Consequently, when frictional resistance with the reversibility volume change matter increases, rotation is controlled, and the coloring ball which rotated in the condition of having displayed the image is held while it has been in the condition. This is the same also about the coloring ball of the non-image display section. Therefore, according to the 1st TSUISUTINGU ball display sheet of this invention, even if disappearance of accidental frictional electrification or a maintenance charge is after image writing, a coloring ball does not rotate, it is stabilized and an image can be held.
[0015] With the 2nd TSUISUTINGU ball display sheet of this invention, all or some of coloring ball consists of reversible volume change matter, by shrinking the coloring ball itself at the time of image writing, and making it a cavity internal surface and non-contact, it changes into a pivotable condition in an insulating liquid, and rotation is controlled by making a cavity internal surface contact by expanding the coloring ball itself after image write-in termination, and increasing frictional resistance. Therefore, even if accidental electrification friction and disappearance of a maintenance charge are after image writing also with the 2nd TSUISUTINGU ball display sheet of this invention, a coloring ball does not rotate, it is stabilized and an image can be held.
[0016] With the 3rd TSUISUTINGU ball display sheet of this invention Some cavity walls [at least] consist of reversible volume change matter. A coloring ball is changed into a pivotable condition in an insulating liquid by expanding or shrinking the wall which consisted of reversibility volume change matter at the time of image writing, and making it a cavity internal surface and non-contact. Rotation of a coloring ball is controlled by making a cavity internal surface contact by contracting or expanding said wall section after image write-in termination, and increasing frictional resistance. Therefore, even if accidental electrification friction and disappearance of a maintenance charge are after image writing also with the 2nd TSUISUTINGU ball display sheet of this invention, a coloring ball does not rotate, it is stabilized and an image can be held.
[0017]
[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained with reference to an accompanying drawing. In addition, the configuration which is common on the TSUISUTINGU ball display sheet 11 explained in the column of said conventional technique is explained using the same sign.
[0018] Drawing 1 shows the partial cross section of the TSUISUTINGU ball display sheet 10 of the 1st operation gestalt. This sheet 10 consists of a translucency sheet 12 made from an ingredient like the thermoplastic elastomer (for example, styrene-styrene butadiene rubber (SBS)) which causes reversible deformation lower [it is substantially transparent and] than the coloring ball which that degree of hardness mentions later, or rubber material. the cavity 14 of a large number with the interior spherical in the translucency sheet 12 -- being regular (the shape

of for example, a grid) -- array formation is carried out. The coloring ball 16 is held in the cavity 14. The cavity 14 is greatly formed a little rather than the size of the coloring ball 16. It fills up with an insulating liquid 18 like a silicone oil between the internal surface of a cavity 14, and the coloring ball 16. In the insulating liquid 18, the polymer gel particle 26 which is the reversible volume change matter is distributed. Each of such cavities 14 constitutes a pixel in a sheet 10.
[0019] The coloring ball 16 has two front faces where optical properties differ. The coloring ball 16 has white hemisphere 16w in one side, and, specifically, already has a black hemisphere in one side. These colors are colored by including a white-pigments particle in the polymer which is the component of white hemisphere 16w, and including a black pigment particle in the polymer which is the component of black hemisphere 16b. As a component of the coloring ball 16, styrene resin, styrene-acrylate resin, sodium sulfonation polyester, styrene-methacrylate resin, or a styrene-methacrylate-acrylic-acid terpolymer is used. Moreover, the diameter dozens of micrometers or less of the coloring ball 16 is about 20 micrometers in 10 thru/or magnitude preferably.
[0020] Moreover, the coloring ball 16 has the front face which is two from which an electrification property differs, i.e., a white hemisphere front face, and a black hemisphere front face. Thereby, the dipole moment has arisen inside the coloring ball 16. Thus, forming, respectively with the ingredient which is covered with the film which has F-potential which is different in the front face of each hemispheres 16w and 16b as an approach of producing the dipole moment, respectively, which forms a ball with a ferroelectric ingredient and is made to carry out polarization in each hemisphere opposite direction and which has a work function which is different in each hemispheres 16w and 16b etc. occurs. Thus, when predetermined electric field are applied to the coloring ball 16 which the dipole moment has produced, the coloring ball 16 will rotate. Here, white hemisphere 16w shall have the charge of forward (+), and black hemisphere 16b shall have the charge of negative (-).
[0021] The polymer gel particle 26 has the property which carries out a volume change reversibly as the insulating liquid 18 will be absorbed and it will expand, if it returns to ordinary temperature while escaping from the insulating liquid 18 and contracting, if heat is applied. As a polymer gel ingredient which has such a property, the bridge formation object of a macromolecule with LCST (minimum criticality eutectic temperature) is desirable. As a concrete compound, the bridge formation object of alkylation cellulosics, such as a bridge formation object of copolymers of two or more components, such as a bridge formation object of [N-alkylation (meta) acrylamides], such as Pori N-isopropyl acrylamide, N-alkylation (meta) acrylamide and an acrylic acid (meta) and its metal salt, acrylamide, or (meta) acrylic-acid alkyl ester, a bridge formation object of polyvinyl methyl ether, methyl cellulose, ethyl cellulose, and hydroxypropylcellulose, etc. is mentioned.
[0022] Then, actuation of the sheet 10 which consists of the above configuration is explained. By applying predetermined electric field before image formation, the sheet 10 rotates and is equal to the condition that all the coloring balls 16 turned each white hemisphere 16w in the same direction, as shown in drawing 1 . Thereby, when a sheet 10 is seen from the sheet surface 12a side, the whole sheet is visible to white.
[0023] As shown in drawing 2 to the sheet 10 in this condition at the time of image writing, while applying heat to a sheet 10, electric field 24 are applied to the desired cavity 14 with the external electrodes 20 and 22 arranged on both sides of a sheet 10. With said heating, the polymer gel particle 26 in a cavity 14 escapes from the insulating liquid 18, and contracts. Thereby, frictional resistance with polymer gel 26 decreases, and the coloring ball 16 will be in a pivotable condition.
[0024] Thus, with the coloring ball 16 which changed into the pivotable condition, while being drawn according to an operation of said electric field 24 to the electrode 20 with which positive voltage was impressed by black hemisphere 16b which carried out negative polarity electrification, it is drawn to the electrode 22 with which the minus electrical potential difference was impressed by white hemisphere 16w which carried out straight polarity electrification. Consequently, the coloring ball 16 is visible to a black dot, when black hemisphere 16b rotates in the condition of having countered the electrode 20 and sees from the sheet surface 12a side. Rotation is controlled with the maintenance charge (it illustrates by + and -) given to surface 12a

and rear-face 12b of a sheet 10 with the external electrodes 20 and 22, and the coloring ball 16 rotated by electric field 24 is held. Thus, by rotating many coloring balls 16 alternatively, a desired image can be written in a sheet 10.

[0025] Thus, after an image is written in, a sheet 10 is returned to the environment (ordinary temperature) generally used. Then, as shown in drawing 3 , absorb the insulating liquid 18, the polymer gel particle 26 expands, and coloring ball 16 front face and cavity 14 internal surface will be contacted it. By this, rotation will be controlled because frictional resistance with the polymer gel particle 26 increases, and the coloring ball 16 will be held in the condition as it is. The holding power of the coloring ball 16 in this case is powerful compared with the case of what is depended on a maintenance charge. Moreover, rotation is controlled and held about the coloring ball 16 16 of the non-image section which did not rotate by electric field not being impressed, i.e., a coloring ball with the condition of having turned white hemisphere 16w to the sheet surface 12a side, by the polymer gel particle 26 which expanded. Therefore, without according to the sheet 10, the coloring ball 16 rotating, even if disappearance of accidental frictional electrification or a maintenance charge is after image writing, it is stabilized and an image can be held.

[0026] Next, TSUISUTINGU ball display sheet 10a of the 2nd operation gestalt is explained. The polymer gel particle 26 is not distributed in the insulating liquid 18, but a different point from the sheet 10 of said 1st operation gestalt in this sheet 10a consists of polymer gel ingredients which the coloring ball 16 whole contracts with heat and which were mentioned above, as shown in drawing 4 .

[0027] In this sheet 10a, by heating at the time of image writing, coloring ball 16 the very thing escapes from the insulating liquid 18, and contracts. by this, the coloring ball 16 will be in the internal surface and non-contact condition of a cavity 14, and frictional resistance is reduced greatly, and pivotable -- a condition -- ** In this condition, the same with having explained the sheet 10 of the 1st operation gestalt, by applying the suitable electric field for the desired cavity 14, the coloring ball 16 rotates and the writing of an image is performed. After image write-in termination, if returned to the environment (ordinary temperature) where sheet 10a is generally used, as shown in drawing 5 , coloring ball 16 the very thing absorbs the insulating liquid 18, and expands, and the internal surface of a cavity 14 will be contacted. By this, rotation of the coloring ball 16 will be controlled and it will be held at a condition as it is because frictional resistance increases sharply. Therefore, even if there is disappearance of the accidental frictional electrification after image writing or a maintenance charge also by sheet 10a, the coloring ball 16 does not rotate, it is stabilized and an image can be held.

[0028] In addition, although the polymer gel ingredient constituted all of the coloring balls 16 from said sheet 10a, some coloring balls 16 may consist of polymer gel ingredients. For example, when only black hemisphere 16b is constituted from a polymer gel ingredient among the coloring balls 16, at the time of ordinary temperature, black hemisphere 16b absorbs the insulating liquid 18, and expands. Thereby, as shown in drawing 6 , the coloring ball 16 becomes a form like an egg, the both ends contact the internal surface of a cavity 14, and rotation of the coloring ball 16 is controlled.

[0029] Next, TSUISUTINGU ball display sheet 10b of the 3rd operation gestalt is explained with reference to drawing 7 and 8. This sheet 10b is formed by pasting up only a sheet periphery (not shown) for 1st sheet 12c and 2nd sheet 12d mutually by approaches, such as ultrasonic welding, as shown in drawing 7 . Bridge wall 13a used as the wall of a cavity 14 is formed in 1st sheet 12c. The clearance is formed in this bridge wall 13. This clearance is filled up with polymer gel 28. The bridge wall 13 which sandwiches polymer gel 28 from both sides also plays the role which supports the polymer gel 28 expanded and contracted so that it may be a comparatively soft ingredient and may mention later. The cavity 14 is filled up with the insulating liquid 18 while the coloring ball 16 is held. In addition, 1st sheet 12c which has the above bridge walls 13 can be formed by precision micro processing which used a photolithography, etching, etc.

[0030] The polymer gel 28 of this operation gestalt has the property which carries out a volume change reversibly as it will escape from the insulating liquid 18 and will contract, if it returns to ordinary temperature while absorbing the insulating liquid 18 and expanding, if heat is applied. As

this polymer gel 28, IPN (mutual invasion network structure object) of the polymer gel of two components which carry out hydrogen bond etc. is desirable. As a concrete compound, the IPN object which consists of a bridge formation object of the Pori (meta) acrylamide and a bridge formation object of the Pori (meta) acrylic acid and its partial neutralization object (what carried out the metal chlorination of the acrylic-acid unit partially), the IPN object which consists of the bridge formation object of a copolymer and the bridge formation object of the Pori (meta) acrylic acid which use Pori (meta) acrylamide as a principal component, its partial neutralization object, etc. are mentioned.

[0031] In sheet 10b which has the above-mentioned structure, at the time of the ordinary temperature before an image is written in, although the coloring balls 16 are a bridge wall 13 and non-contact, it is inserted into 1st sheet 12c and 2nd sheet 12d, and they are held. Moreover, all the coloring balls 16 are arranged with the condition of having turned white hemisphere 16w to the 1st sheet 12c side, by impressing predetermined electric field before image writing.

[0032] When writing an image in such sheet 10b, heat is applied to sheet 10b. Thereby, as shown in drawing 8 , polymer gel 28 absorbs the insulating liquid 18, and expands, and a cavity 14 is extended in the sheet thickness direction. Consequently, the coloring ball 16 will be in a pivotable condition, when it becomes 1st sheet 12c and 2nd sheet 12d, and non-contact and frictional resistance decreases greatly. In this condition, as the sheet 10 of the 1st operation gestalt explained, electric field are applied to the desired cavity 14, the coloring ball 16 is rotated, and an image is written in. After image write-in termination, if returned to the environment (ordinary temperature) where sheet 10b is generally used, polymer gel 28 will escape from the insulating liquid 18, will contract, and will return to the condition which shows in drawing 7 . any of the having displayed white ground's, without [the coloring ball 16 which rotates and displays an image by this, and] rotating coloring ball 16 -- although -- 1st sheet 12c and 2nd sheet 12d will be contacted, frictional resistance will increase, and rotation will be controlled and held. Therefore, also by sheet 10b of this operation gestalt, even if disappearance of accidental frictional electrification or a maintenance charge is after image writing, it is stabilized and an image can be held.

[0033] In addition, although polymer gel 28 was filled up with said sheet 10b into the clearance between bridge walls 13, a part of bridge wall 13 very thing which is a cavity wall as shown in drawing 9 may consist of polymer gels 28.

[0034] Moreover, although polymer gel 28 constituted some walls of a cavity 14 from filling up the clearance between bridge walls 13 with said sheet 10b, as shown in drawing 10 , the wall of cavities 14 other than bridge wall 13 may consist of polymer gels 28 and 28 (only either may be prepared). In this case, polymer gel 28 has the same property (namely, heat contraction) as the polymer gel particle 26 in the sheet 10 of the 1st operation gestalt, and holds the coloring ball 16 by inserting between the polymer gel 28 which expanded, respectively, and 28 at the time of ordinary temperature. Furthermore, as shown in drawing 11 , all of the walls of a cavity 14 may consist of polymer gels 28. Also in this case, polymer gel 28 has the same property as the polymer gel particle 26 in the sheet 10 of the 1st operation gestalt. Therefore, polymer gel 28 will change the coloring ball 16 into a pivotable condition, as it contracts with heating and is shown in drawing 11 , and it will hold the coloring ball 16 by expanding at the time of ordinary temperature and contacting the perimeter of a ball.

[0035] By the way, although the polymer gel which produces a volume change with heat was used in said sheet 10b, the polymer gel which replaces with this and produces a volume change by light may be used. As a compound of such polymer gel, there are the polystyrene and Pori (N and N-dimethyl acrylamide) where polyvinyl methyl ether, the leuco of a triphenylmethane color, and leuco hydroxide were introduced into the side chain in part, polyacrylamide, etc., for example. When polyvinyl methyl ether is used, since the insulating liquid 18 will be absorbed and this will expand if infrared radiation is irradiated, it can acquire the same effectiveness as said sheet 10b by performing image writing, where infrared radiation is irradiated.

[0036] Although the coloring ball (namely, ball of positive/negative electrification by monochrome coloring) 16 which has the front face which is two from which an optical property and an electrification property differ was used in the above operation gestalt and its modification, the

coloring ball which has three or more front faces where an optical property differs from an electrification property may be used with the TSUISUTINGU ball display sheet of this invention.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, with the sheet 11 as which the image was displayed as mentioned above, when there was disappearance of the accidental frictional electrification by rubbing by hand etc. or a maintenance charge, the coloring ball of the image display section or the non-image display section may rotate, and there was a problem that it was stabilized and an image could not be held.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

MEANS

[Means for Solving the Problem] In order to solve said problem then, the 1st TSUISUTINGU ball display sheet of this invention It holds the translucency sheet which has the cavity by which array formation was carried out regularly, and in said cavity, and has at least two front faces where an optical property differs from an electrification property. By the electric action A pivotable coloring ball, It has the insulating liquid with which it filled up between the internal surface of said cavity, and said coloring ball, and the reversible volume change matter distributed in said insulating liquid.
[0010] Moreover, the 2nd TSUISUTINGU ball display sheet of this invention It holds the translucency sheet which has the cavity by which array formation was carried out regularly, and in said cavity, and has at least two front faces where an optical property differs from an electrification property. By the electric action A pivotable coloring ball, It has the insulating liquid with which it filled up between the internal surface of said cavity, and said coloring ball, and is characterized by said all or some of coloring ball consisting of reversible volume change matter.
[0011] With the 1st [of said this invention], and 2nd TSUISUTINGU ball display sheets, said reversible volume change matter may produce a volume change with heat.
[0012] Moreover, the 3rd TSUISUTINGU ball display sheet of this invention It holds the translucency sheet which has the cavity by which array formation was carried out regularly, and in said cavity, and has at least two front faces where an optical property differs from an electrification property. By the electric action A pivotable coloring ball, It has the insulating liquid with which it filled up between the internal surface of said cavity, and said coloring ball, and is characterized by forming some walls [at least] of said cavity by the reversible volume change matter.
[0013] With the 3rd TSUISUTINGU ball display sheet of this invention, said reversible volume change matter may produce a volume change by heat or light.
[0014]

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The fragmentary sectional view of the TSUISUTINGU ball display sheet of the 1st operation gestalt.
[Drawing 2] Drawing showing the condition when applying electric field to the cavity of a request of the sheet of drawing 1 , and rotating a coloring ball.
[Drawing 3] Drawing showing the condition that a coloring ball is held by the polymer gel particle, in the sheet of drawing 1 .
[Drawing 4] The fragmentary sectional view of the TSUISUTINGU ball display sheet of the 2nd operation gestalt.
[Drawing 5] Drawing showing the condition that a coloring ball is held within a cavity in the sheet of drawing 4 .
[Drawing 6] Drawing showing the condition that a coloring ball is held within a cavity, in the modification of the 2nd operation gestalt.
[Drawing 7] The fragmentary sectional view of the TSUISUTINGU ball display sheet of the 2nd operation gestalt.
[Drawing 8] Drawing showing the condition that polymer gel expanded, in the sheet of drawing 7 .

[Drawing 9] Drawing showing the modification of the 3rd operation gestalt.
[Drawing 10] Drawing showing another modification of the 3rd operation gestalt.
[Drawing 11] Drawing showing still more nearly another modification of the 3rd operation gestalt.
[Drawing 12] The fragmentary sectional view of the conventional TSUISUTINGU ball display sheet.
[Drawing 13] Drawing showing the condition when applying electric field to the cavity of a request of the sheet of drawing 12 , and rotating a coloring ball
[Description of Notations]
10, 10a, 10b [-- A coloring ball, 16b / -- A black hemisphere, 16w / -- A white hemisphere, 18 / -- 20 An insulating liquid 22 / -- An external electrode, 24 / -- Electric field 26 / -- A polymer gel particle (reversible volume change matter), 28 / -- Polymer gel (reversible volume change matter).] -- A TSUISUTINGU ball display sheet, 12 -- A translucency sheet, 14 -- A cavity, 16

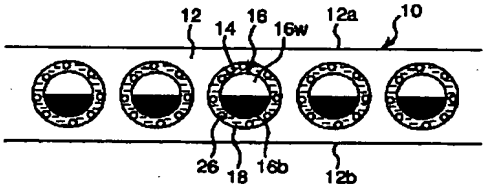
[Translation done.]

* NOTICES *

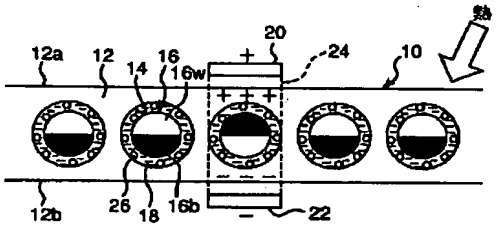
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

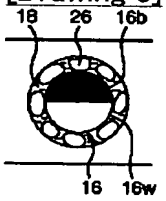
[Drawing 1]



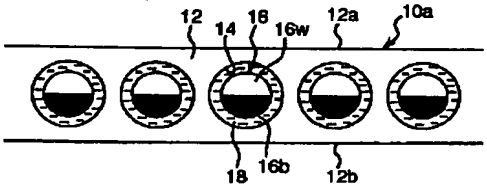
[Drawing 2]



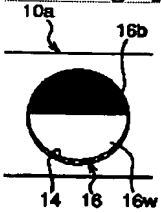
[Drawing 3]



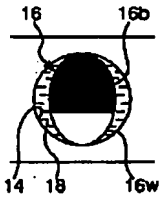
[Drawing 4]



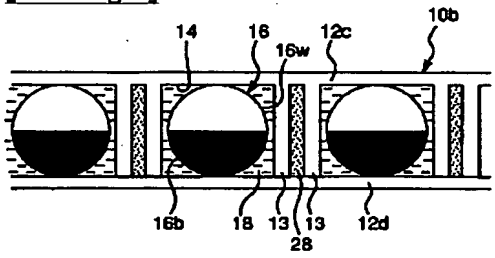
[Drawing 5]



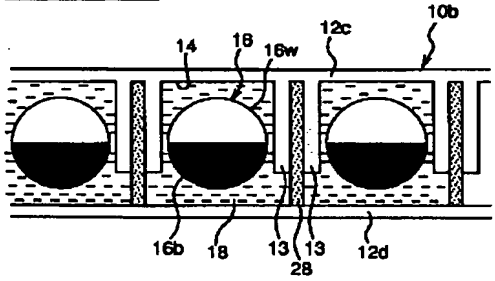
[Drawing 6]



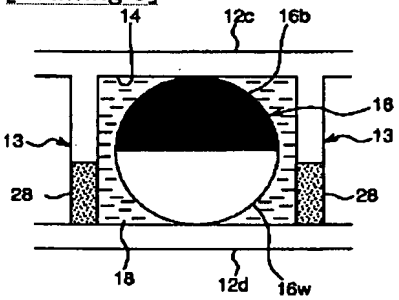
[Drawing 7]



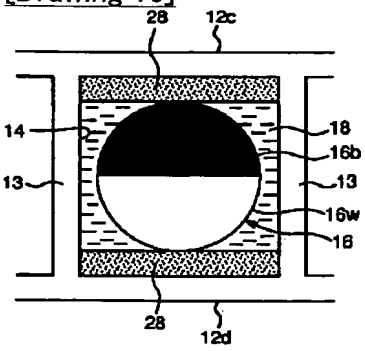
[Drawing 8]



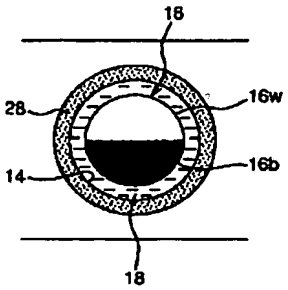
[Drawing 9]



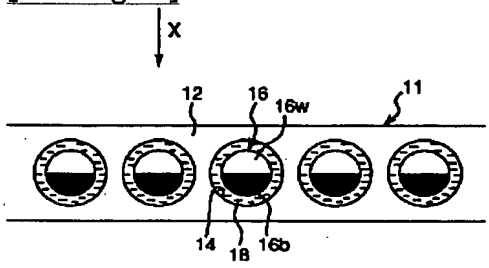
[Drawing 10]



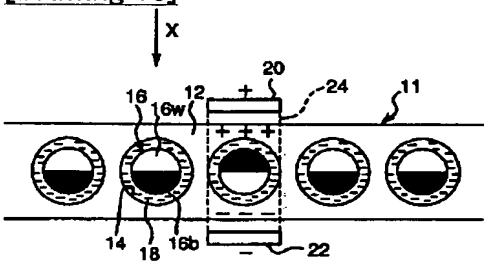
[Drawing 11]



[Drawing 12]



[Drawing 13]



[Translation done.]